Attachment 2

EVALUATION OF ALTERNATIVE PITCHES WITH EMPHASIS ON THE SODERBERG APPLICATION

I. Introduction

Evaluation of candidate binder pitches for the production of anode carbon is essentially the same for the two types of cells used commercially-"prebake" and Soderberg.

Prebaked anodes are formed by blending sized petroleum coke aggregate, butts, and pitch binder, molding this into blocks (with preformed electrical connection sockets) by pressing or vibrating, and baking in ring furnace pits. Electrical connection is provided by aluminum or copper rods, welded or bolted to steel stubs, then fixed into the anode socket with cast iron.

Soderberg anodes are also formed by mixing a sized petroleum coke aggregate with a binder pitch. The resulting mixture is then extruded from the mixer, water-quenched and formed into cobbles or briquettes of green paste. These paste briquettes are added to the top of an operating anode enclosed by a steel casing containing the paste mixture at various stages of baking. This carbon mass is made to slip through the casing at the rate of consumption of the anode in effecting electrolysis. In the case of a VS anode, electrical contact is made by vertical steel pins imbedded in the carbon mass which are pulled and replanted at a higher level as the tip approaches the anode face.

Obviously, the Soderberg technique places an additional rheological requirement on the pitch/coke mixture which is not present in the prebake case. The green paste must ideally redistribute itself uniformly across the anode top without segregation as the pitch initially melts and evolves volatile hydrocarbons in the coking process to form anode carbon. There is also the aspect of filling the pinholes with an acceptable secondary carbon when a pin is pulled and reset. As a result, the Soderberg operation typically requires approximately double the pitch content of a prebake to achieve the necessary rheological behavior. Generally speaking, this situation together with the low-baked anode condition has a deleterious effect on such resulting baked composite properties as density, electrical resistivity, structural strength and anode reactivity. With the Soderberg operation, we are therefore working with an anode with marginal performance characteristics to begin with, as compared to a prebake. As anode quality significantly impacts both the energy efficiency and productivity of a cell, anode formulation is of paramount importance. Variations in pitch characteristics must be restricted to tighter ranges to achieve the compromise between paste rheological requirements and baked carbon properties.

II. Laboratory Evaluation Procedure

Improved anode performance results from minimizing the oxidant-accessible surface and/or minimizing the specific anode surface reactivity. For given materials, both are usually achieved by the combination of coke granulometry and pitch content which tends to provide the densest baked composite. Unfortunately, this cannot be predicted "a priori" by examining the list of properties for a specific pitch and coke because of the highly complex chemical and rheological interactions which occur when pitch and coke are mixed together and baked.

Laboratory tests, therefore, are a necessary screen. If a candidate material does not meet certain testing specifications, there is a high probability it will not perform satisfactorily in the plant. On the other hand, successful lab test characterization does not guarantee good plant performance. The lab tests are necessary but not sufficient conditions to qualify a material for commercial usage. The overall test procedure is as follows:

First, the pitch itself is characterized by the following properties as determined by standard tests and methods.

Softening point

Coking value

% Quinoline insolubles

% Sulfur

% Ash

The pitch is then used with a given coke aggregate to make a paste and the following properties determined.

Green Apparent Density

% Elongation

The paste is then baked under controlled conditions and the following properties of the baked composite determined by standard methods.

Baked Apparent Density

Resistivity

Compressive strength

% Porosity

Air burn

CO_2 reactivity

Carbon consumption

It is the properties of the baked composite which give the best indication of anode performance and its impact on cell production and energy efficiencies.

III. Interpretation of Test Results (Soderberg Operations)

Softening Point

A low softening point results in a high pitch loss and an unsupportably high volatile release rate on heating, giving a weak pitch-coke bond. Generally speaking, higher softening points are better but the pitch requires more expensive treatment. The practical upper limit is usually dictated by the mixing equipment available. Adequate mixing within a reasonable time is typically obtained at a temperature about 60°C above the softening point.

Coking Value

Coking value is a direct measure of the amount of carbon that will result from a unit weight of pitch. Lower coking values imply a higher carbon consumption and a lower mechanical strength. Higher coking values are desirable but the upper limit is dictated by rheological concerns.

Percent Quinoline Insolubles

Increasing QI produces a stronger, more isotropic binder coke, but requires a correspondingly higher optimum pitching level. The converse is true, i.e. lower QI produces a weaker, less isotropic binder coke. The upper limit is usually dictated by the economics of the corresponding increased pitch requirement.

Percent Sulphur

Sulphur is regarded as an undesirable impurity with two major impacts. Anode sulphur is the prime source of SO_x emissions into the potrooms and therefore, is an industrial hygiene concern. Anode sulphur is also a main contributor to pin corrosion and scaling which decreases pin life and increases electrical resistivity of the pin/carbon interface. Additionally, carbon consumption increases with increasing sulphur.

Percent Ash

Increased ash content tends to increase carbon consumption as a result of the catalytic effect of many of the impurities on carbon oxidation by air and/or CO_2.

Apparent Green Density

Apparent green density is used in conjunction with baked apparent density. An acceptable green density is necessary for, but does not guarantee, an acceptable baked density.

Percent Elongation

Elongation is the practical measure of the rheological or temperature/viscosity characteristics of the paste and is directly related to the percent pitch content. Too high an elongation results in a "liquid paste" which promotes anode segregation. An elongation which is too low, results in a dry, inadequately bound anode. In each case, the important general properties of the anode deteriorates.

Baked Apparent Density

This is the most important indicator of overall anode quality. A higher baked apparent density implies minimum oxidant-accessible surface with improved resistivity, porosity and reactivity factors. Generally, the higher the better, however, there is an upper limit about 1.65 g/cm^3 where the increasing degree of isotropy gives unacceptable thermal characteristics.

Resistivity

This is a direct measure of the electrical resistance of the anode carbon. The lowest possible value is obviously desired. Typically, Soderberg anode carbon resistivity is 30 percent higher than prebaked anode carbon.

Compressive Strength

Compressive strength should be maximized. Lowered compressive strength results in an anode which is more likely to break up from mechanical, thermal or chemical means. In the Soderberg case, experience indicates that 4,000 psi is the minimum acceptable value.

Percent Porosity, Air Burn, CO_2 Reactivity

These factors are indicators of the carbon reactivity which translates into overall anode performance.

Carbon Consumption

This test measures relative carbon consumption under simulated electrolytic conditions. It is a very informative, yet time-consuming procedure providing additional verification to any conclusions drawn from the foregoing tests. It is the only test which incorporates all the important anode properties (excluding air burn) simultaneously.

IV. Acceptable Properties for the Soderberg Application

Years of plant operating experience has allowed us to establish acceptable ranges (illustrated in Table I) for the properties determined by the foregoing tests. We can confidently conclude that usage of a material which gives test values outside these ranges in a negative sense would result in deteriorating anode performance. Significant departure would result in totally unacceptable anode operation, with a serious negative impact on plant production, energy and labor efficiencies.